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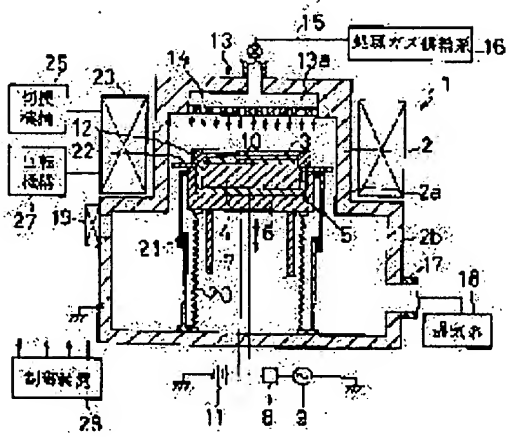
(54) PROCESSING DEVICE AND METHOD

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a processing device and a method, where a work can be efficiently processed by protecting it against shading damage.

SOLUTION: A magnetron reactive ion etching device 1 is equipped with a unit composed of electrodes which are opposed to each other sandwiching a semiconductor device 3 between them, a high-frequency power supply 9 which generates an electronic field on the unit of electrodes, a dipole ring magnet 23, and a switching mechanism 25. The dipole ring magnet 23 forms two magnetic field states, one is that a magnetic field is possessed of a component that crosses the direction of an electric filed at right angles or in parallel with the semiconductor device 3 and the other is that a magnetic field near to the surface of the semiconductor device 3 is so set in intensity as to make a Larmor radius larger than an average free path of electron. By the switching mechanism 25 controlled by a control device 26, a first magnetic field state is switched to a second magnetic field state and vice versa on a prescribed timing.



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CLAIMS

Claim(s)]

Claim 1] The electrode unit which consisted of a processing container, and the 1st electrode which is arranged in said processing container and counters on both sides of a processed object and the 2nd electrode, A raw gas supply means to supply raw gas in said processing container, and a flueing means to exhaust the gas in said processing container, The electric-field means forming which supplies high-frequency power to said electrode unit, and forms electric field between said 1st electrode and said 2nd electrode, The 1st magnetic field condition which forms a magnetic field parallel to said processed object or it has the component which intersects perpendicularly with said direction of electric field in said electrode unit, The magnetic field means forming in which the magnetic field strength near the front face of said processed object forms two magnetic field conditions of a magnetic field where a Larmor radius becomes large, and the becoming 2nd magnetic field condition from an electronic mean free path, The processor characterized by having the magnetic field status-switching means which switches said 1st magnetic field condition and said 2nd magnetic field condition.

Claim 2] The processor according to claim 1 characterized by what is formed in a magnetic field parallel to said processed object or it has the component which intersects perpendicularly said 2nd magnetic field condition with said direction of electric field.

Claim 3] The processor according to claim 1 or 2 characterized by what the gas which has a reactant ion kind is used for said raw gas, and magnetron reactivity ion processing is carried out for to said processed object.

Claim 4] Said magnetic field status-switching means is a processor given in claim 1 characterized by what it has for the change-over controlling mechanism which switches said 1st magnetic field condition and said 2nd magnetic field condition to predetermined timing thru/or any 1 term of 3.

Claim 5] A processor given in claim 1 characterized by what a uniform magnetic field is formed for on said processed object in the state of said 1st magnetic field condition and said 2nd magnetic field thru/or any 1 term of 4.

Claim 6] Said magnetic field means forming consists of two or more electromagnets arranged so that said electrode unit may be inserted. Said magnetic field status-switching means Two steps of the amount of the 1st current and the amount of the 2nd current constitute the amount of the current passed on said electromagnet switchable. A processor given in claim 1 characterized by what the current of said amount of the 1st current is passed on said electromagnet, said 1st magnetic field condition is formed, the current of said amount of the 2nd current is passed on said electromagnet, and said 2nd magnetic field condition is formed for thru/or any 1 term of 5.

Claim 7] It is a processor given in claim 1 which said magnetic field means forming consists of two or more permanent magnets arranged so that said electrode unit may be inserted, and is characterized by what said magnetic field status-switching means arranges said two or more permanent magnets in the dipole condition, and forms said 1st magnetic field condition, the sense of the magnetic pole of two or more of said permanent magnets is changed, and said 2nd magnetic field condition is formed for thru/or any 1 term of 5.

Claim 8] The processed object installation process which arranges a processed object between the electrode units which consisted of electrodes of the pair arranged in a processing container, The reduced pressure process which decompresses the inside of said processing container to a predetermined pressure, and the raw gas supply process which supplies raw gas in said processing container, The electric-field formation process which supplies high-frequency power to said electrode unit, and forms electric field between two electrodes, The magnetic field formation process which forms the 1st magnetic field condition parallel to said processed object or it has the component which intersects perpendicularly with said direction of electric field in said electrode unit, The art to which magnetic field strength near the front face of said processed object is characterized by having the magnetic field status-switching process switched to the 2nd magnetic field condition that a Larmor radius becomes large from an electronic mean free path from said 1st magnetic field condition.

Claim 9] The art according to claim 8 characterized by what is formed in a magnetic field parallel to said processed ›bject or it has the component which intersects perpendicularly said 2nd magnetic field condition with said direction of :lectric field.

Claim 10] The art according to claim 8 or 9 characterized by what the gas which has a reactant ion kind is used for said aw gas, and magnetron reactivity ion processing is carried out for to said processed object.

Claim 11] Said magnetic field status-switching process is an art given in claim 8 characterized by what is switched to aid 2nd magnetic field condition to predetermined timing thru/or any 1 term of 10.

Claim 12] An art given in claim 8 characterized by what a uniform magnetic field is formed for on said processed objec n the state of said 1st magnetic field condition and said 2nd magnetic field thru/or any 1 term of 11.

Translation done.]

)ETAILED DESCRIPTION

Detailed Description of the Invention]
0001]
Field of the Invention] Especially this invention relates to the processor which can stop the shading damage of a)rocessed object, and its art about a processor and its art.
0002]
Description of the Prior Art] There is a magnetron reactive ion etching system which performs etching processing :fficiently using the magnetic field from a magnetron among the reactive ion etching systems.
0003] A magnetron reactive ion etching system supplies high-frequency power to the electrode of the pair first arranged n a processing container, forms electric field, and makes the plasma form near the front face of the processed object hich carried out induction of the discharge of etching gas, and was laid on the electrode, for example, a semi-conductor afer. Next, a magnetic field is made to form horizontally to a semi-conductor wafer by magnetic field means forming, or example, a permanent magnet. Thereby, an electron is made to cause cyclotron movement (screw motion), and the requency where an electron and a neutral particle collide is made high. Ionization of the reactant gas near the front face)f a semi-conductor wafer is promoted by the collision with these electrons and a neutral particle. And incidence of this on is carried out to the processing side of a semi-conductor wafer, and etching advances efficiently by the effectiveness)f both the spatter operations and chemical reactions by ion.
0004] In such a magnetron reactive ion etching system, it becomes important to form a horizontally uniform magnetic ield to a semi-conductor wafer. This is because dispersion within a field of the etch rate to a semi-conductor wafer will ırise if a horizontally uniform magnetic field cannot be formed. The dipole ring magnet used for a magnetron reactive on etching system at drawing 7 is shown.
0005] As shown in drawing 7 , the dipole ring magnet 101 is formed in the structure which has arranged two or more ınisotropy segment pillar-shaped magnets 103 at equal intervals on the body 102 of a dipole ring formed in the shape of ı ring. The anisotropy segment pillar-shaped magnet 103 is arranged so that a level magnetic field uniform as a whole nay be formed, and the direction of magnetization may shift gradually. This dipole ring magnet 101 is arranged on the)utside of the processing container 104, and a magnetic field B is horizontally formed to the semi-conductor wafer 105.
0006] Moreover, the dipole ring magnet 101 is formed in the structure which can be rotated along the hoop direction. \nd by rotating this dipole ring magnet 101, a uniform rotation magnetic field is formed in the level direction to the :emi-conductor wafer 105, and the plasma consistency on the semi-conductor wafer 105 becomes homogeneity.
0007]
Problem(s) to be Solved by the Invention] By the way, in magnetron reactive ion etching with large magnetic field :trength, there is a problem that a shading damage tends to enter, for example at the time of exaggerated etching. In orde) o explain this shading damage, the mimetic diagram of the transistor at the time of exaggerated etching is shown in lrawing 8 .
0008] As shown in drawing 8 , a transistor 111 is a transistor of the MOS mold with which gate dielectric film 113 and he gate electrode 114 were formed on the semi-conductor wafer 112. The 1st interlayer insulation film 115 is formed on he semi-conductor wafer 112 with which gate oxide 113 and the gate electrode 114 are not formed, and the metal wiring .16 is formed on the 1st interlayer insulation film 115 and the gate electrode 114. The 2nd interlayer insulation film 117 s formed on the metal wiring 116, and the resist 118 is arranged on the 2nd interlayer insulation film 117. And by the esist 118, the 2nd interlayer insulation film 117 of the part by which a mask is not carried out is etched by magnetron eactive ion etching, and the hole 119 is formed of it.
0009] Between magnetron reactive ion etching, the constraint (constraint by cyclotron movement) by the magnetic field s received, the rate (rate which goes downward from on drawing 8) at which an electron goes in the hole 119 direction

becomes slow, and an electron stops being able to enter easily in a hole 119. On the other hand, the electrified ion cation) cannot receive constraint by the magnetic field easily due to the reasons nil why the mass is heavy etc., compared with an electron. For this reason, the rate which goes in the hole 119 direction of a cation is quicker than an electronic rate, and becomes easy to enter in a hole 119. Therefore, as shown in drawing 8 , the charge up of the cation 20 is easy to be carried out to the bottom of a hole 119 at the time of exaggerated etching, and an electron 120 becomes that the charge up is easy to be carried out on a resist 118. Consequently, the difference of potential arises, and a current is shown by the arrow head 122 which passes along gate dielectric film 113 flows, and it is easy to produce the shading damage by which gate dielectric film 113 is destroyed.

0010] Before it performs owner magnetic field high density plasma etching and a pattern dissociates completely on the occasion of carrying out patterning of the metal wiring connected to the gate electrode to JP,5-308055,A as an approach of preventing degradation of such an insulator layer, the proposal that gate electrode wiring can be formed is made by switching to non-magnetic field low consistency plasma etching, and performing patterning, without causing degradatior of gate oxide.

0011] Like this proposal, if it switches to non-magnetic field low consistency plasma etching from owner magnetic field high density plasma etching, it is possible it to be lost for that an electron receives constraint of a magnetic field and to suppress degradation of an insulator layer like a shading damage. However, if it switches to non-magnetic field low consistency plasma etching from owner magnetic field high density plasma etching, an etch rate will slow down greatly. For this reason, if owner magnetic field high density plasma etching is not performed until just before etching processing s completed, the meaning of magnetron reactive-ion-etching original of performing etching processing efficiently will be lost.

0012] On the other hand, when owner magnetic field high density plasma etching is performed until just before etching processing is completed, there is a possibility that gate oxide may be exposed from a part of etched hole. And by exposure of this gate oxide, the electron on a semi-conductor wafer will be unevenly distributed, and the new problem that a charge-up damage arises will occur.

0013] This invention is made in view of the above-mentioned problem, and the purpose is to offer the processor which can perform efficient processing, and its art while stopping the shading damage of a processed object.

0014]

Means for Solving the Problem] In order to attain the above-mentioned purpose, the processor concerning the 1st iewpoint of this invention The electrode unit which consisted of a processing container, and the 1st electrode which is arranged in said processing container and counters on both sides of a processed object and the 2nd electrode, A raw gas supply means to supply raw gas in said processing container, and a flueing means to exhaust the gas in said processing container, The electric-field means forming which supplies high-frequency power to said electrode unit, and forms electric field between said 1st electrode and said 2nd electrode, The 1st magnetic field condition which forms a magnetic field parallel to said processed object or it has the component which intersects perpendicularly with said direction of electric field in said electrode unit, The magnetic field means forming in which the magnetic field strength near the front face of said processed object forms two magnetic field conditions of a magnetic field where a Larmor radius becomes large, and the becoming 2nd magnetic field condition from an electronic mean free path, It is characterized by having the magnetic field status-switching means which switches said 1st magnetic field condition and said 2nd magnetic field condition.

0015] With this configuration, in the phase of wanting to process efficiently, it switches to the 1st magnetic field condition with a magnetic field status-switching means, and efficient processing is performed. Moreover, in the phase hich a shading damage tends to generate, it switches to the 2nd magnetic field condition with a magnetic field status-switching means, and processing is performed. In the state of this 2nd magnetic field, since a magnetic field where a Larmor radius becomes large from an electronic mean free path exists, processing speed is not slowed down greatly. oreover, a Larmor radius is larger than an electronic mean free path, the rate of the electron diffused so that a magnetic field may be crossed increases, and this electron becomes easy to advance into the bottom of the hole of a processing side. For this reason, the shading damage of a processed object can be stopped.

0016] If it forms in a magnetic field parallel to said processed object or it has the component which intersects the 2nd magnetic field condition perpendicularly with the direction of electric field, it is hard coming to slow down processing speed, and efficient processing can be performed. If magnetron reactivity ion processing is carried out to a processed object using the gas which has a reactant ion kind in raw gas, processing will advance efficiently by the effectiveness of both the spatter operations and chemical reactions by ion.

0017] If it has the change-over controlling mechanism which switches the 1st magnetic field condition and the 2nd magnetic field condition to a magnetic field status-switching means to predetermined timing, a magnetic field condition

ill be switched automatically. If a uniform magnetic field is formed on a processed object in the state of the 1st nagnetic field condition and the 2nd magnetic field, a uniform rotation magnetic field will be formed in the direction evel on a processed object, and the plasma consistency of a processed object will become homogeneity.

0018] Magnetic field means forming consists of two or more electromagnets arranged so that an electrode unit may be nserted. A magnetic field status-switching means is constituted by two steps of the amount of the 1st current, and the mount of the 2nd current switchable in the amount of the current passed on an electromagnet. If the current of the mount of the 1st current is passed on an electromagnet, the 1st magnetic field condition is formed, the current of said mount of the 2nd current is passed on an electromagnet and the 2nd magnetic field condition is formed, a magnetic fielc condition will be switched to the 2nd magnetic field condition from the 1st magnetic field condition by switching the mount of a current to the amount of the 2nd current from the amount of the 1st current.

0019] Magnetic field means forming consists of two or more permanent magnets arranged so that an electrode unit may be inserted, if a magnetic field status-switching means arranges two or more permanent magnets in the dipole condition, nd forms the 1st magnetic field condition, the sense of the magnetic pole of two or more permanent magnets is changed nd said 2nd magnetic field condition is formed, in the 1st magnetic field condition, a big magnetic field can be formed nd processing will be performed efficiently.

0020] The processed object installation process which arranges a processed object between the electrode units which consisted of electrodes of a pair with which the art concerning the 2nd viewpoint of this invention has been arranged in a processing container, The reduced pressure process which decompresses the inside of said processing container to a predetermined pressure, and the raw gas supply process which supplies raw gas in said processing container, The electric-field formation process which supplies high-frequency power to said electrode unit, and forms electric field between two electrodes, The magnetic field formation process which forms the 1st magnetic field condition parallel to said processed object or it has the component which intersects perpendicularly with said direction of electric field in said electrode unit, From said 1st magnetic field condition, magnetic field strength near the front face of said processed objec s characterized by equipping a Larmor radius with the magnetic field status-switching process switched to the 2nd nagnetic field condition which becomes large from an electronic mean free path.

0021] With this configuration, in the phase of wanting to process efficiently, the 1st magnetic field condition is formed nd processing is performed. Moreover, in the phase which a shading damage tends to generate, it switches to the 2nd nagnetic field condition at a magnetic field status-switching process, and processing is performed. In the state of this 2nd magnetic field, since a magnetic field where a Larmor radius becomes large from an electronic mean free path exists processing speed is not slowed down greatly. Moreover, that Larmor radius is larger than the mean free path of the electron generated from raw gas, the rate of the electron diffused so that a magnetic field may be crossed increases, and his electron becomes easy to advance into the bottom of the hole of a processing side. For this reason, the shading lamage of a processed object can be stopped.

0022] If it forms in a magnetic field parallel to said processed object or it has the component which intersects the 2nd nagnetic field condition perpendicularly with the direction of electric field, it is hard coming to slow down processing speed, and efficient processing can be performed. If magnetron reactivity ion processing is carried out to a processed object using the gas which has a reactant ion kind in raw gas, processing will advance efficiently by the effectiveness of both the spatter operations and chemical reactions by ion.

0023] If it switches to the 2nd magnetic field condition to predetermined timing, a magnetic field condition will be utomatically switched by the magnetic field status-switching process. If a uniform magnetic field is formed on a processed object in the state of the 1st magnetic field condition and the 2nd magnetic field, a uniform rotation magnetic ield will be formed in the direction level on a processed object, and the plasma consistency of a processed object will become homogeneity.

0024]

Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained according to drawing 1 - drawing 4 . Drawing 1 shows the sectional view of the magnetron reactive ion etching system of the gestalt of this operation.

0025] As shown in drawing 1 , the magnetron reactive ion etching system 1 is equipped with the processing container 2 hich performs etching processing, and the dipole ring magnet 23 which forms a magnetic field in the processing container 2.

0026] The processing container 2 consists of 2 steps of up of minor diameter which is formed approximately cylindrical nd performs etching processing of semiconductor device 3 2a, and lower 2b of the major diameter which carries in or akes out a semiconductor device 3 in the processing container 2. This processing container 2 is formed with the metal, or example, aluminum.

0027] In the processing container 2, the installation base 4 in which a semiconductor device 3 is laid is arranged. The nstallation base 4 is formed with a metal, for example, aluminum, and functions as the 1st electrode. This installation)ase 4 is supported by the susceptor 6 of a conductor through the electric insulating plate 5. This susceptor 6 is :onstituted possible [rise and fall] by the ball-thread device in which it has a ball thread 7, and the installation base 4 semiconductor device 3) is arranged by making it go up and down this susceptor 6 at predetermined height.
0028] RF generator 9 is connected to the installation base 4 through the blocking capacitor 8. RF generator 9 supplies .3.56MHz high-frequency power to the installation base 4, and the auto-bias of the installation base 4 is carried out to :lectronegative potential by operation of a blocking capacitor 8.
0029] The electrostatic chuck 10 for carrying out electrostatic adsorption of the semiconductor device 3 is formed in the op face of the installation base 4. The electrostatic chuck 10 is formed in the structure to which the electrode intervened)etween insulators, and the electrode is connected to DC power supply 11. And by impressing an electrical potential lifference to an electrode from DC power supply 11, it adsorbs according to Coulomb force and a semiconductor device) (semi-conductor wafer) is laid on the installation base 4.
0030] The focal ring 12 for centralizing a plasma consistency on the processing side of a semiconductor device 3 is ormed in the upper periphery (perimeter of the semiconductor device 3 in the condition that the semiconductor device 3 as laid in the installation base 4) of the installation base 4. The focal ring 12 is formed with the conductive ingredient, or example, single crystal silicon.
0031] The refrigerant passage which is not illustrated is established in the interior of the installation base 4, and it has :tructure which can control a semiconductor device 3 to predetermined temperature by circulating the refrigerant of)redetermined temperature in this refrigerant passage.
0032] The shower head 13 is formed in up 2a of the processing container 2 so that the installation base 4 may be :ountered. This shower head 13 functions as the 2nd electrode, and the shower head 13 and the installation base 4 :onstitute an electrode unit as an electrode of a pair.
0033] The shower head 13 is formed in the interior at the hollow structure of having centrum 13a. The blow-of-gas hole .4 of a large number which make centrum 13a and the inside of the processing container 2 open for free passage is ormed in the lower part of the shower head 13. Moreover, the gas supply line 15 which supplies etching gas in centrum .3a (processing container 2) is connected to the upper part of the shower head 13. The raw gas supply system 16 which :upplies gas, such as reactant gas, for example, the gas which has the reactant ion kind of a halogen system, and dilution ;as, for example, Ar, helium, etc., is connected to this gas supply line 15. And the etching gas supplied from the raw gas :upply system 16 blows off to homogeneity in the processing side of a semiconductor device 3 through centrum 13a of a ;as supply line 15 and the shower head 13, and the blow-of-gas hole 14.
0034] An exhaust hole 17 is formed in the lower side attachment wall of lower 2b of the processing container 2, and the :xhaust air system 18 is connected to the exhaust hole 17. The exhaust air system 18 consists of vacuum pumps etc. The nside of the processing container 2 is decompressed to a predetermined pressure (degree of vacuum) by actuation of this acuum pump. Moreover, the gate valve 19 which opens and closes the carrying-in outlet of a semiconductor device 3 is ormed in the up side attachment wall of lower 2b of the processing container 2.
0035] The end of the bellows 20 constituted possible [telescopic motion] is airtightly connected to the lower limit of :usceptor 6, and this other end is airtightly connected to the base of the processing container 2 in it. This bellows 20 is ormed with stainless steel (SUS). Moreover, the bellows covering 21 is formed in the exterior of bellows 20.
0036] Moreover, the baffle plate 22 is formed in the outside of the focal ring 12. Two or more holes for making raw gas low in the lower 2b direction of the processing container 2 are prepared in this baffle plate 22. This baffle plate 22 has lowed with the processing container 2 through susceptor 6 and bellows 20.
0037] Around up 2a of the processing container 2, the dipole ring magnet 23 is arranged so that it may face across the :pace between the installation base 4 and the shower head 13 (henceforth processing space). The horizontal sectional iew of the dipole ring magnet 23 neighborhood is shown in drawing 2 .
0038] As shown in drawing 2 , the dipole ring magnet 23 is equipped with two or more segment magnets 24. The :egment magnet 24 is arranged in the shape of a ring, after having been supported by the supporter material which is not llustrated. With the gestalt of this operation, 16 segment magnets 24 are arranged in the shape of a ring, and the :lectromagnet constituted from an iron core and a coil by the segment magnet 24 is used.
0039] The change-over device 25 in which pass a current to each segment magnet 24, and a magnetic field is made to orm is connected to the dipole ring magnet 23. The change-over device 25 is constituted by two steps of the amount of he 1st current, and the amount of the 2nd current with few amounts of a current than the amount of the 1st current :witchable in the amount of the current passed to each segment magnet 24. And if the current of the amount of the 1st :urrent flows to each segment magnet 24, the 1st magnetic field condition which forms in processing space the magnetic

ield which goes to an one direction as a whole will be formed. Moreover, if the current of the amount of the 2nd current lows to each segment magnet 24, it will be the magnetic field where magnetic field strength is weaker than the 1st nagnetic field condition of going in an one direction to processing space as a whole, and the 2nd magnetic field condition that the magnetic field strength near the front face of a semiconductor device 3 serves as a magnetic field here a Larmor radius becomes large from an electronic mean free path will be formed.

0040] The timing which switches the current which the change-over device 25 supplies to the coil of the segment nagnet 24 is controlled by the control unit 26 which consisted of microprocessors etc. The optimal switching time from he 1st magnetic field condition to the 2nd magnetic field condition in each processing conditions is beforehand egistered into the internal memory of a control unit 26. This switching time says the time amount which can make an bject the thinnest, without the substrate layer formed in the lower layer of the object of etching processing also exposin ne place. In addition, switching time is defined based on the experimental result by various etching conditions. A ontrol device 26 will measure the processing time by the internal timer, if etching processing is started, and if it listinguishes having reached switching time, it will output change-over directions of the purport which switches the urrent supplied to a coil to the amount of the 2nd current to the change-over device 25.

0041] Moreover, the rolling mechanism 27 which rotates the dipole ring magnet 23 along the hoop direction is onnected to the dipole ring magnet 23. And where the 1st magnetic field condition or the 2nd magnetic field condition s formed, if the dipole ring magnet 23 is rotated by the rolling mechanism 27, a uniform rotation magnetic field will be ormed in the direction level to a semiconductor device 3.

0042] Next, the magnetron reactive-ion-etching approach using the magnetron reactive ion etching system 1 constituted is mentioned above is explained. In addition, each process explained below is controlled by the control unit 26, and is erformed by the control unit 26.

0043] First, where the installation base 4 is dropped according to the ball-thread device in which it has a ball thread 7, a ate valve 19 is opened, and a semiconductor device 3 is conveyed on the installation base 4 in the processing container with the conveyance means which is not illustrated. Next, the installation base 4 is raised according to the ball-thread levice in which it has a ball thread 7, to the condition shown in drawing 1 . And impress a predetermined electrical otential difference to the electrode of the electrostatic chuck 10 from DC power supply 11, a semiconductor device 3 is nade to adsorb according to Coulomb force, and it lays on the installation base 4 (processed object installation process).

0044] Next, a gate valve 19 is closed and the processing container 2 is sealed, and it decompresses until it becomes a redetermined pressure (degree of vacuum) about the inside of the processing container 2 through an exhaust hole 17 ith the vacuum pump of the exhaust air system 18 (reduced pressure process). And etching gas is blown off from the aw gas supply system 16 to homogeneity in the processing side of a semiconductor device 3 through a gas supply line .5, the shower head 13, and the blow-of-gas hole 14, and the inside of the processing container 2 is held (raw gas supply rocess)., predetermined pressures, for example, 45mTorr(s)

0045] If etching gas is supplied to the processing side of a semiconductor device 3, the high-frequency power whose requency is 13.56MHz and whose power is 1500W will be supplied to the installation base 4 from RF generator 9. Then, the auto-bias of the installation base 4 is carried out to electronegative potential by operation of a blocking apacitor 8, and the electric field which go in the installation base 4 direction from the shower head 13 are formed electric-field formation process). Induction of the discharge of etching gas is carried out by this electric field, and the lasma is formed of it near the front face of the semiconductor device 3 laid on the installation base 4. Furthermore, this lasma concentrates near the front face of a semiconductor device 3 with the focal ring 12.

0046] If the plasma is formed near the front face of a semiconductor device 3, the current of the amount of the 1st urrent will be passed to the segment magnet 24 through the change-over device 25. And while forming the homogeneity nagnetic field (the 1st magnetic field condition) which goes in an one direction to processing space as a whole with the lipole ring magnet 23, the dipole ring magnet 23 is rotated through a rolling mechanism 27, and a uniform rotation nagnetic field is formed in the direction level to a semiconductor device 3 (magnetic field formation process).

0047] If a magnetic field is formed in the direction level to a semiconductor device 3, the frequency where a lifting, and his electron and neutral particle collide [the electron in processing space] cyclotron movement will become high. onization of the etching gas near the front face of a semiconductor device 3 is promoted by the collision with these lectrons and a neutral particle. Consequently, incidence of the ion is carried out to a semiconductor device 3, and tching advances efficiently by the effectiveness of both the spatter operations and chemical reactions by this ion.

0048] If etching advances and it becomes the optimal switching time to the 2nd magnetic field condition from the 1st nagnetic field condition, the current passed to each segment magnet 24 through the change-over device 25 will be witched to the amount of the 2nd current. Thereby, the magnetic field strength near the front face of a semiconductor levice 3 forms the 2nd magnetic field condition which consists of a weak uniform rotation magnetic field which is exten

o which the Larmor radius becomes large from the mean free path of the electron generated from etching gas (magnetic ield status-switching process).

0049] Here, the relation between an electronic mean free path and a Larmor radius is explained. Since a Larmor radius s in inverse proportion to magnetic field strength, a Larmor radius will become large if magnetic field strength becomes . eak. If magnetic field strength becomes weak and a Larmor radius becomes large from a mean free path, an electron :annot fully be rotated but the rate of the electron which does not receive the constraint from cyclotron movement magnetic field) will increase. For this reason, an electron becomes easy to advance into the processing side (bottom of he hole formed of etching processing) of a semiconductor device 3. An electron arrives at the processing side of a :emiconductor device 3, and the ununiformity (difference of potential) of the potential in the field of a semiconductor levice 3 stops for this reason, producing it. Therefore, the shading damage which destroys the insulator layer which is :asy to generate at the time of exaggerated etching etc. can be stopped.

0050] The formula of the diffusion which crosses an electronic magnetic field can explain this. If the magnetic field rom a perpendicular direction is formed to the electron which moves in accordance with electric field, an electron will)e restrained by the magnetic field and cyclotron movement will be caused, but if a magnetic field is crossed without eceiving the constraint from this magnetic field and it goes on to a processing side (diffusion), it will be hard coming to ;enerate a shading damage. The diffusion D which crosses the magnetic field of this electron is expressed with the ollowing formulas.

)=D0/(1+(lambdam/r) 2)

)0 is [an electronic mean free path and r of a diffusion coefficient and lambdam] Larmor radii here. The diffusion hich crosses an electronic magnetic field from this formula, so that lambdam/r is small becomes large. Since it is the :quare of lambdam/r, if a Larmor radius becomes large from a mean free path, Diffusion D will become large so that a liffusion coefficient may be approached, and will especially become easy to advance to a processing side, without an :lectron receiving the constraint from a magnetic field.

0051] On the other hand, since a weak magnetic field exists even if it is in the 2nd magnetic field condition, in some :lectrons in processing space, a lifting, and this electron and neutral particle collide cyclotron movement, and ionization)f the etching gas near the front face of a semiconductor device 3 is promoted. For this reason, an etch rate is not slowed lown greatly.

0052] After etching processing is completed, supply of the etching gas from the raw gas supply system 16 is stopped. Next, the installation base 4 is dropped according to the ball-thread device in which it has a ball thread 7, and impression)f the electrical potential difference to the electrostatic chuck 10 from DC power supply 11 is canceled. Finally, a gate alve 19 is opened and a semiconductor device 3 is moved out of the processing container 2 with the conveyance means hich is not illustrated.

0053] In order to check the effectiveness of the gestalt of this operation, magnetron reactive ion etching was performed ising the antenna MOS as shown in drawing 3 . In addition, Antenna MOS is formed on [112] the semi-conductor afer (8 inches), and drawing 3 shows one of these by the mimetic diagram.

0054] As shown in drawing 3 , the antenna MOS 31 consists of the semi-conductor wafer 32, gate oxide 33, the 1st nsulator layer 34, an electrode layer 35, and the 2nd insulator layer 36. The 1st insulator layer 34 is formed in the part by hich gate oxide 33 is arranged on the semi-conductor wafer 32, and the gate oxide 33 on the semi-conductor wafer 32 s not arranged. The electrode layer 35 is formed on gate oxide 33 and the 1st insulator layer 34. On the electrode layer 35, the 2nd insulator layer 36 is formed so that an electrode layer 35 may be covered. Moreover, two or more holes 37 hich reach an electrode layer 35 are formed in the 2nd insulator layer 36. Etching processing was performed at the intenna MOS 31 of the above structure. And it measured about whether gate oxide 33 has caused dielectric breakdown)y this etching.

0055] This measurement followed [whether gate oxide 33 energizes by etching processing, and] a total of 112 on the :emi-conductor wafer 32, as shown in drawing 4 . Consequently, it was only five pieces that gate oxide 33 is destroyed. hen measurement with the same said of what carried out etching processing (it is etching processing only in the 1st nagnetic field condition) with the conventional magnetron reactive ion etching system for the comparison was)erformed, it was 55 pieces that gate oxide is destroyed. Thus, when etching processing was performed using the nagnetron reactive ion etching system 1 of the gestalt of this operation, destruction of gate oxide 33 could be decreased)r less [conventional] to 1/10, and it has checked also from the stopping [a shading damage] experiment.

0056] Since according to the gestalt of this operation the 1st magnetic field condition and the 2nd magnetic field :ondition are switched by the optimal time amount and etching processing is performed, as explained above, while being ible to stop the shading damage which is easy to generate at the time of exaggerated etching etc., efficient etching)rocessing can be performed.

0057] In addition, this invention is not limited to the gestalt of the above-mentioned implementation, and may use a permanent magnet for the segment magnet 24. For example, as shown in drawing 5 (a), while arranging the sense of the magnetic pole of the segment magnet 24 in the dipole condition and forming the 1st magnetic field condition, the sense of the magnetic pole of the segment magnet 24 is changed, and the 2nd magnetic field condition is formed. In this case, in the 1st magnetic field condition, a big magnetic field can be formed and still more efficient processing can be performed.

0058] The 2nd magnetic field condition may be in a-less magnetic field condition substantially that the magnetic field strength near the front face of a processed object should just be the magnetic field where a Larmor radius becomes large from an electronic mean free path. In this case, if the sense of the magnetic pole of the segment magnet 24 is arranged in the multipole condition as shown in drawing 5 (b), the 2nd magnetic field condition can be made to form.

0059] Moreover, as shown in drawing 6 , you may make it the structure which formed two steps of dipole ring magnets 23 in the perimeter of up 2a of the processing container 2 in the vertical direction. In addition, drawing 6 is the mimetic diagram which illustrated only 2 sets of segment magnets 24 from the side face among the dipole ring magnets 23, in order to make an understanding easy. In this case, if the sense of the magnetic pole of the segment magnet 24 of the lower berth is switched, line of magnetic force can make the 2nd magnetic field condition [-less magnetic field / target / which goes to the lower berth / real / from an upper case] form like drawing 6 (b) from the 1st magnetic field condition of the dipole condition of drawing 6 (a).

0060] You may be the structure which has arranged electromagnetic wave shielding which can appear between the processing container 2 and the dipole ring magnets 23 frequently. In this case, if electromagnetic wave shielding is taken out from between the processing container 2 and the dipole ring magnets 23, the 1st magnetic field condition will be formed, and if electromagnetic wave shielding is inserted between the processing container 2 and the dipole ring magnet 23, the 2nd magnetic field condition will be formed.

0061] With the gestalt of this operation, although the magnetron reactive ion etching system was explained, it is applicable not only to this but for example, a magnetron reactivity ion CVD system, a magnetron reactivity ion sputtering system, a magnetron plasma etching system, magnetron plasma-CVD equipment, a magnetron plasma sputtering system, etc.

0062]

Effect of the Invention] Efficient processing can be performed while stopping the shading damage of a processed object according to this invention, as explained above.

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.**** shows the word which can not be translated.
.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

Brief Description of the Drawings]
Drawing 1] It is the sectional view showing the magnetron reactive ion etching system of the gestalt of operation of this nvention.
Drawing 2] It is the sectional view showing the dipole ring magnet of the gestalt of operation of this invention.
Drawing 3] It is the mimetic diagram showing the antenna MOS of the gestalt of operation of this invention.
Drawing 4] It is the mimetic diagram showing the condition of measuring the shading damage of the antenna MOS of he gestalt of operation of this invention.
Drawing 5] (a) is the mimetic diagram of the dipole ring magnet in the 1st magnetic field condition of the gestalt of nother operation, and, similarly (b) is the mimetic diagram of the dipole ring magnet in the 2nd magnetic field :ondition.
Drawing 6] (a) is the mimetic diagram of the dipole ring magnet in the 1st magnetic field condition of the gestalt of nother operation, and, similarly (b) is the mimetic diagram of the dipole ring magnet in the 2nd magnetic field :ondition.
Drawing 7] It is the mimetic diagram showing the conventional dipole ring magnet.
Drawing 8] It is a mimetic diagram for explaining a shading damage.
Description of Notations]
. Magnetron Reactive Ion Etching System
! Processing Container
3 Semiconductor Device
4 Installation Base
) RF Generator
.3 Shower Head
.6 Gas Supply System
.8 Exhaust Air System
!3 Dipole Ring Magnet
!4 Segment Magnet
!5 Change-over Device
!6 Control Unit

Translation done.]

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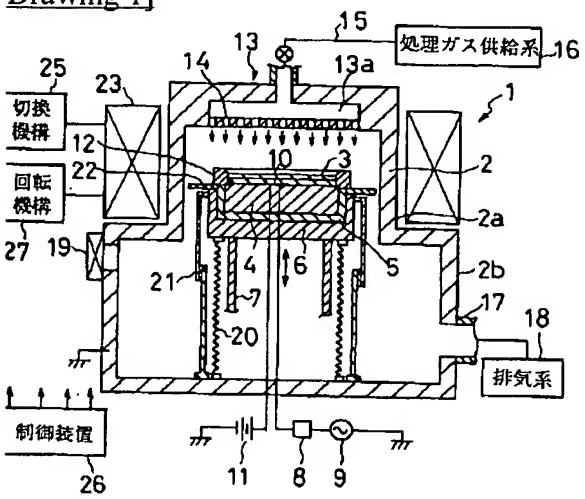
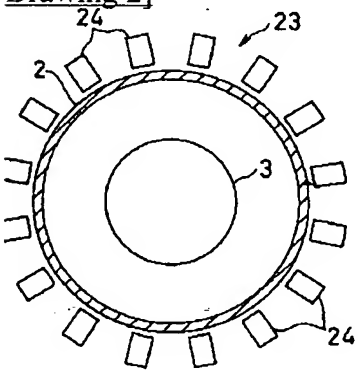
..This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

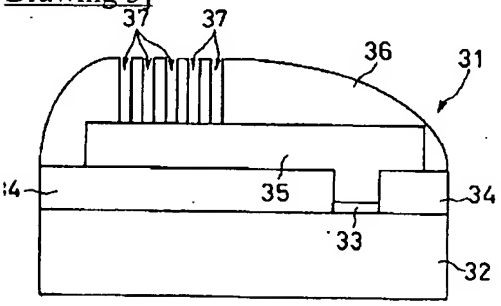
Drawing 1]



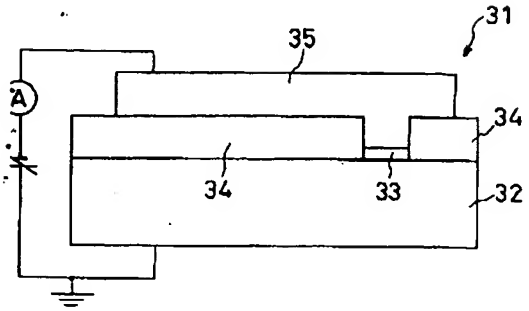
Drawing 2]



Drawing 3]

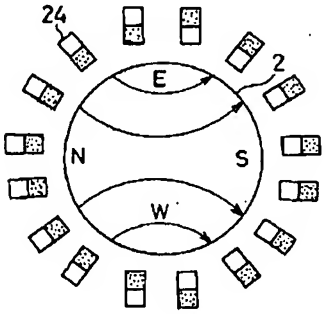


Drawing 4]

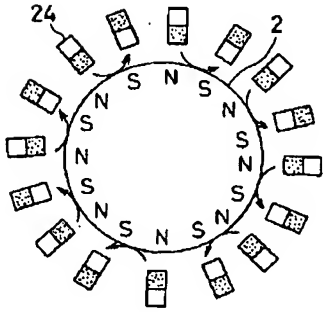


Drawing 5]

a) ダイポール

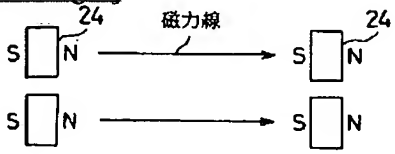


b) マルチポール



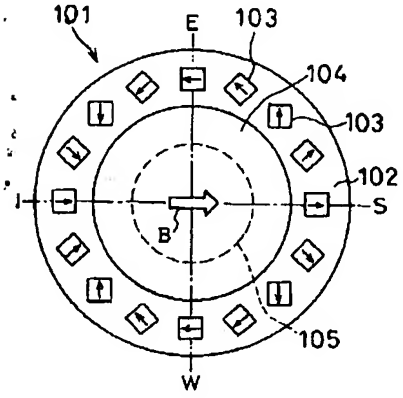
Drawing 6]

a)

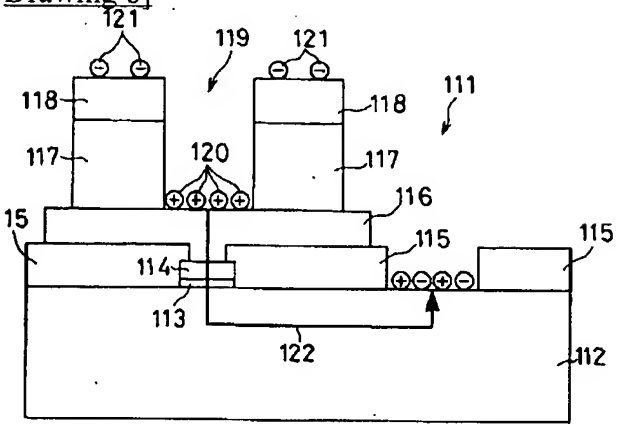


b)

Drawing 7]



Drawing 8]



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